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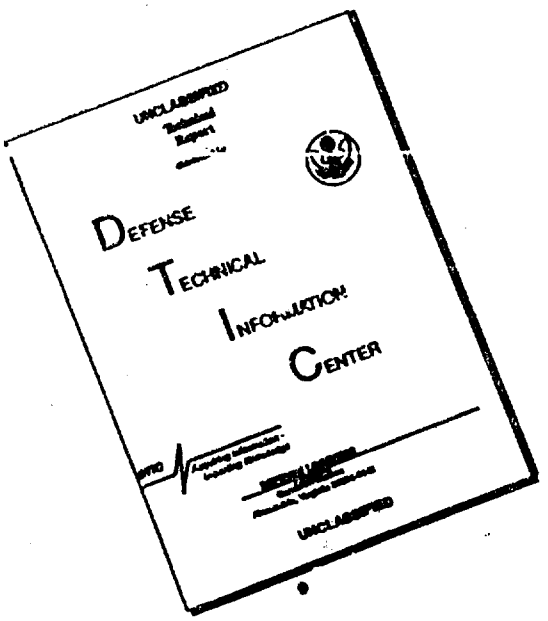

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THE STRUCTURE OF A NATURAL TULAREMIA FOCUS OF THE FLOOD PLAIN TYPE

[Following is a translation of an article by N. G. Olsuf'yev, V. V. Kucheruk, N. I. Makarov, V. P. Borodin, V. G. Petrov and Ye. P. Selyanin in the Russian-language journal Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii (Journal of Microbiology, Epidemiology and Immunobiology), Moscow, No 4, 1955, pp. 27-31.]

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In the literature the opinion has been established that in natural foci of tularemia of the flood plain type the maintenance and circulation of the infectious disease are carried out by the water rat and blood-sucking Diptera, chiefly mosquitoes. The latter are only mechanical vectors of the infectious disease and are of essential significance in the spread of the infection only in the epizootic season. In the opinion of various authors, the infection is carried from one epizootic season to the next by the water rat, because of the presence of the latent form of tularemia and exacerbation of the infectious process in it when there is a deterioration in its existential conditions.

Studies of recent years (Romanova and others, 1954; Olsuf'yev and others, 1954) have shown that the structure of the natural tularemia foci of the flood plain type is much more complicated, which is evidenced by the results of a study of the existential conditions of a natural tularemia focus in the flood plain of a large river in a semi-desert region presented in the present article. The study was made under our direction for three years (1952-1954) by a large group of workers—P. A. Kartushin, A. P. Kondaleva, V. A. Mikhaleva, Z. I. Murav'yeva, I. N. Nefedova, N. A. Nikitina, P. ... Pantelev, A. P. Samsonova, P. A. Spitsin, N. V. Tumikova, A. I. Khlyustova and N. S. Yamolova.

The flat, relatively even surface of the flood plain was bounded on the west and south by the main river bed; on the north and east, by a large

arm of At. In the region of our work the width of the flood plain ranges from 30 to 40 kilometers. A large number of eriks [shallow channel in the river delta] pinched off from the main bed and arms or streams of water connecting these main water bodies divide the flood plain into numerous islands. About 15 percent of the area of the flood plain is occupied by bodies of water which, as a rule, are shallow and small in size. The flood plain extends 400 kilometers from northwest to southeast.

The climate here is of a clearly expressed continental nature: the summer is hot and dry; the winter is cold with little snow. A little precipitation falls here, about 300 millimeters a year.

The late and long floods are very characteristic: the water begins to rise in the middle of April and reaches its highest level in the third 10-day period of May; the overflow stops at the end of June. Because of an abundance of moisture there is tremendous development of vegetation on the flooded territory in the summer.

The flood plain abounds in water rats, which have high-grade green food in adequate quantity for the entire summer and can reproduce actively from April to September. On the flood plain territory there are also the meadow vole, house mouse, field mouse, and in places the common hamster [Cricetus cricetus] and some other small mammals. In the flood plain ixodial ticks Dermacentor marginatus and Rhipicephalus rossicus are distributed in a mosaic pattern but in large numbers in places.

In the flood plain in the summer mosquitoes appear in large numbers (chiefly Aedes vexans and A. caspius); there are also large numbers of black-flies (Simulium maculatum) and horseflies (Tabanus, Chrysops, Chrysozona).

In the past, on the flood plain territory, cases of tularemia in people have been repeatedly noted from arthropod-borne transmission and partly from infection sustained in hunting.

The flood plain territory is not uniform. A study of it made it possible to distinguish five landscape regions which differ from one another in a combination of features.

1. The region of solid inundation with flood waters occupies the central low and level portion of the flood plain and constitutes about 40 percent of its entire area. The census of the water rat as well as of blood-sucking Diptera, particularly mosquitoes and horseflies, reaches a maximum here. Ixodial ticks are absent.

2. The embankment of the river arm along the river bed is a region which extends out along the right bank of the river arm for about 50 kilometers and is from 0.7 to 3 kilometers wide; it occupies about 7 percent of the entire flood plain area. Characteristic of this entire region is an abundance of Dermacentor marginatus and Rhipicephalus rossicus ticks (the former is more numerous). In the summer these ticks are parasitic here in the larval and nymphal phases on the water rat, vole, field mouse, hamster, and hedgehog [Erinaceus europaeus]. Blood-sucking Diptera, particularly black-flies, are numerous.

3. The embankments of the internal eriks along the river bed: territorially, this region does not constitute a single area and is broken up in separate patches and strips in the midst of the region of solid inundation; it occupies about 6 percent of the flood plain. Characteristic of

the region is the distribution of the tick Rhipicephalus rossicus, which in various areas is abundant; the tick Dermacentor marginatus is sparse and found sporadically. Among the small mammals there is a predominance of mice, particularly field mice; the water rat and hedgehog are numerous. Blood-sucking Diptera, particularly black-flies, are numerous.

4. The embankment along the main river bed: in the lower and middle portions it constitutes a strip 2-5 kilometers wide; in the upper part it drains into the embankment along the bed of the river arm, forming an extensive area up to 25 kilometers wide. The region occupies 20 percent of the area of the flood plain; the terrain is elevated; the water bodies are located in deeply serrated trenches. The spring high water floods no more than 20-30 percent of the area. Characteristic of the region is the low census of the water rat and other rodents as well as of ixodial ticks. There are fewer blood-sucking Diptera than in other parts of the flood plain.

5. The region of insular inundation occupies the western, more elevated portion of the flood plain, being located between the region of solid inundation and the embankment along the main river bed; it amounts to about 22 percent of the entire flood plain area. The composition of the fauna in this region changes markedly from year to year, depending on the maximum level of the flood: during years of high flood levels the water rat is abundant and is among the predominant species. During years of low flood levels its census is markedly reduced, and toward autumn it almost disappears, while among the small rodents there is a clear-cut predominance of the meadow vole. Ixodial ticks are widespread over the region, but apparently they are few in numbers on its major portion. An exception is constituted by areas bounding the embankment along the river arm, where D. marginatus is quite abundant. Mosquitoes are numerous only during years with a high flood level.

In the flood plain which we studied the floods have a dual effect on the reservoirs and vectors of tularemia. Inundation of the major portion of the flood plain for a long time does not permit the existence of a number of species here and it displaces others from the flooded areas temporarily. Thus, for example, tularemia reservoirs—the ixodial ticks D. marginatus and R. rossicus—live only in those areas of the flood plain which are not flooded at all or which are flooded for a short time. During years of high flood levels considerable areas of the flood plain are almost entirely liberated of meadow voles and mice, and are again settled by these animals relatively slowly and gradually during the summer and autumn.

Along with the unfavorable effects of the inundation, it is essential for a number of species. According to our data, during years of high flood levels an appreciable increase is observed in the census of blood-sucking Diptera (mosquitoes, black-flies). Tremendous water areas assure the mass breeding of these insects. An abundance of the water rat in the flood plain is possible only as the result of the favorable effect of the flood on the vegetation growing near the water. The accumulation of small rodents on a localized area as the result of their displacement by the spring high water is also of essential significance in maintaining natural tularemia foci, about which we shall talk below.

Through a bacteriological study of the reservoirs and vectors of tularemia, the presence of the infectious disease was established in the

focus in all three years of our work. Spontaneously infected D. marginatus ticks were found every year, and infected R. rossicus ticks were found in 1954. In all, during the three years, 37 cultures of the tularemia microbe were isolated from ticks.

All findings of spontaneously infected ticks were made in two regions: on the embankment along the arm of the river bed and on the embankments of the internal creeks along the river bed. In the first region infected ticks were found every year: in 1952, at one point; in 1953, three points; in 1954, four points. In the second region they were found only once. In other landscape regions no tularemia cultures were isolated, although the number of ticks studied was quite large.

Tularemia epizootics among rodents were not found in any of the years of our work. However, the marked increase in the percentage of infected ticks in 1954 in one of the points of the embankment along the bed of the river arm makes us believe that in the summer of 1953 a local tularemia epizootic had occurred here.

Dissection of more than 6000 water rats, caught in a number of points in the region of solid inundation at places where they had been concentrated in the pre-flood and flood periods (April-June), in the laboratory showed that the animals were free of tularemia. Therefore, during the years in which diffuse tularemia epizootics were absent, the infection was maintained on a very limited territory of permanently active or "elementary" natural tularemia foci, occupying no more than 10-15 percent of the flood plain area.

Our studies showed that the elementary foci are relatively stable; they are found only in certain landscape regions of the flood plain (second and third) and coincide with places where ixodial ticks are abundant (the description of these regions has been given above). The population of small mammals proper to the elementary foci in various years is sparse and, specifically, there are practically no permanent water rat settlements here. This animal appears here in appreciable numbers only at the flood peak, when the water has displaced it from the region of solid inundation. The concentration of water rats and other small rodents on the territory of elementary foci caused by the flood coincides in time with the period of mass parasitism of larvae and nymphs of D. marginatus and R. rossicus. Because of this, a considerable number of the larvae and nymphs are not sustained on permanent warm-blooded inhabitants of the focus but on migrants. The territory of the elementary foci is, for the latter, a relatively short-lasting refuge from the water and the flood. The presence of tick foci in the flood plain is caused specifically by the seasonal abundance of warm-blooded hosts of the young phases of ixodial ticks.

The same phenomenon maintains the existence of elementary tularemia foci on very small areas. The elementary foci here, therefore, are of a multiple-host and multiple-vector character.

In all the other landscape regions, constituting 87 percent of the flood plain territory, the infection is carried out of the elementary foci in the form of diffuse epizootics only temporarily, under certain conditions. The latter can evidently occur only in years when a high water rat census coincides with a high flood level. Under these conditions, because of the mass accumulation of the water rat on areas occupied by

elementary foci, active epizootics occur among the animals. Animals concentrated on small areas are prone to attacks by mosquitoes, which breed in increased numbers because of the high flood level. As is well known, mosquitoes are very active transmitters of tularemia. The extensive participation of mosquitoes in the spread of the infectious disease among water rats at the time of an incipient tularemia epizootic is beyond doubt as far as we are concerned. Specifically through mosquitoes and some other blood-sucking Diptera, the epizootic can spread rapidly among water rats beyond the limits of the elementary natural foci of the infection. Because blood-sucking Diptera are only mechanical vectors of tularemia, they do not play a part in the subsequent maintenance of the infectious disease from one warm season to the next. In the focus which we studied, prolonged preservation of the infectious disease is accomplished by ixodial ticks and, particularly, by R. rossicus, apparently, whose development from larva to imago can take as long as three years.

In the mechanism of maintaining natural foci of tularemia the "outbursts" of the infectious disease to cover large territories, which occur periodically, undoubtedly play an important part. Thereby, an increase of the infectious disease occurs in the elementary foci themselves, expressed in a considerable rise in the number of infected ticks and partial extension of the area occupied by individual elementary foci. In addition, there may be a renewal of foci in which, under the influence of some random factors, the infection had disappeared in the preceding period.

It should be noted that cases of tularemia among people observed in the past occurred chiefly and primarily on the territory of the embankment along the bed of the river arm and embankments of the internal ériks, that is, within the limits of the disposition of elementary natural tularemia foci or areas adjacent to them.

In recent years, because of the introduction of solid vaccination coverage, cases of tularemia have stopped completely in the flood plain.

The rapidly occurring reclamation of the flood plain for pastures, orchards and gardens is including those territories on which new elementary natural foci of tularemia are located. This is considerably reducing the area of the foci, but the portion which remains continues to be potentially dangerous, and reduction and complete elimination of the disease can be achieved only as the result of the incorporation of a certain combination of measures.

In the focus studied water rat hunting, conducted in recent years on a large scale, is undoubtedly the most important factor holding back the increase in the water rat census. All-possible future propaganda is needed on hunting the water rat and on the participation of even larger population segments in it.

The control of ticks, which are long-term reservoirs of the infectious disease in the interepizootic period, should be considered one of the active means of eliminating elementary tularemia foci.

Conclusions

1. In the large river valley studied natural foci of tularemia in the interepizootic periods are not widespread over the entire flood plain

but are located strictly in certain landscape regions which occupy no more than 10-15 percent of the flood plain area.

2. These permanently active or elementary foci of tularemia are located on small unflooded areas which are among the extensive territories solidly inundated during the floods. The elementary foci are stable—the tularemia infection is found in them every year.

3. The elementary foci are characterized by their multiple-vector and multiple-host nature. The maintenance and circulation of the infection in them are maintained by two species of ixodial ticks—Dermacentor marginatus and Rhipicephalus rossicus—and by a number of species of rodents highly sensitive to tularemia—the water rat, meadow vole, house mouse and common hamster.

4. A characteristic feature of the elementary foci is the seasonal concentration of small rodents on their territory, particularly the water rat, which is brought about by the flood. A considerable number of the larvae and nymphs of ixodial ticks feeds on these rodents and is responsible for maintaining the tularemia infection.

5. With the aim of eliminating elementary tularemia foci, extensive ixodial tick control, increased water rat hunting, as well as the regular control of mouse-like rodents are necessary.

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